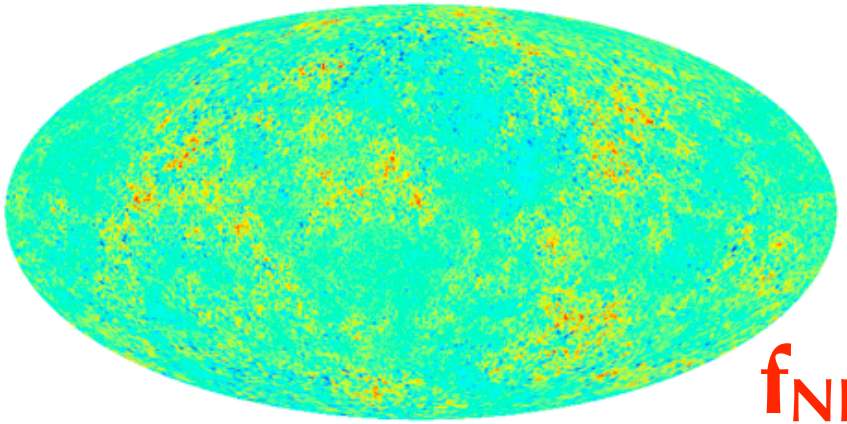
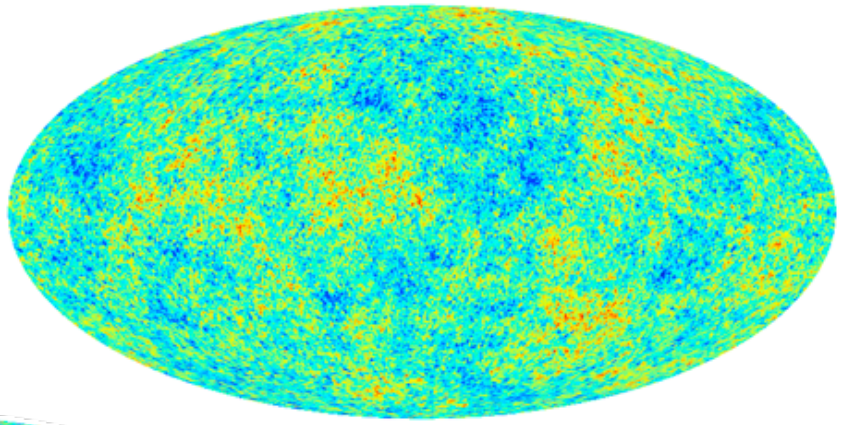
Large-Scale Structure: Next Frontier for Tests of Inflation

Dragan Huterer
University of Michigan

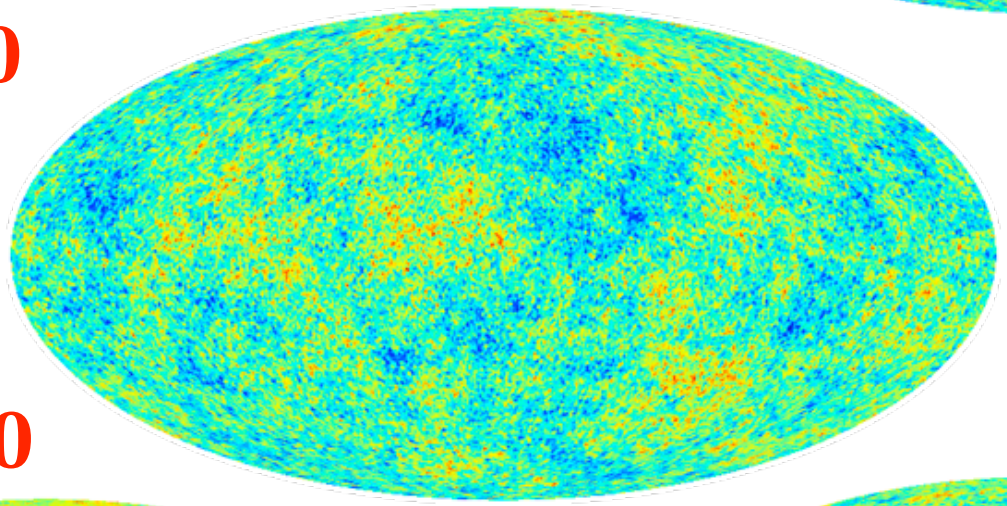


f_{NL}= -5000

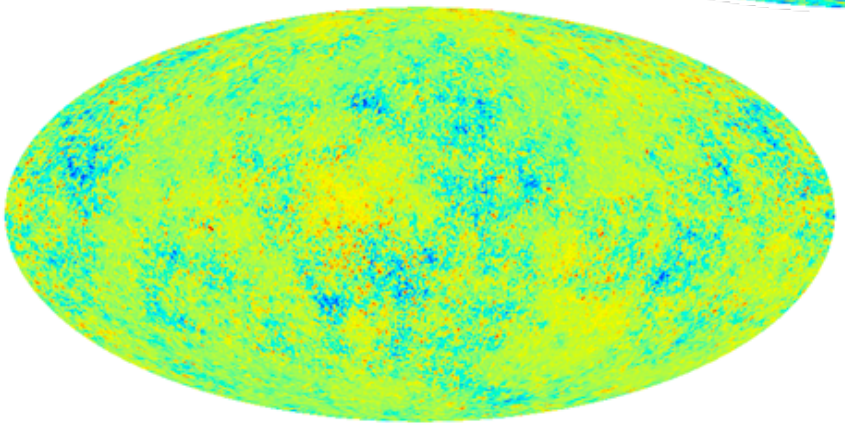


f_{NL}= -500

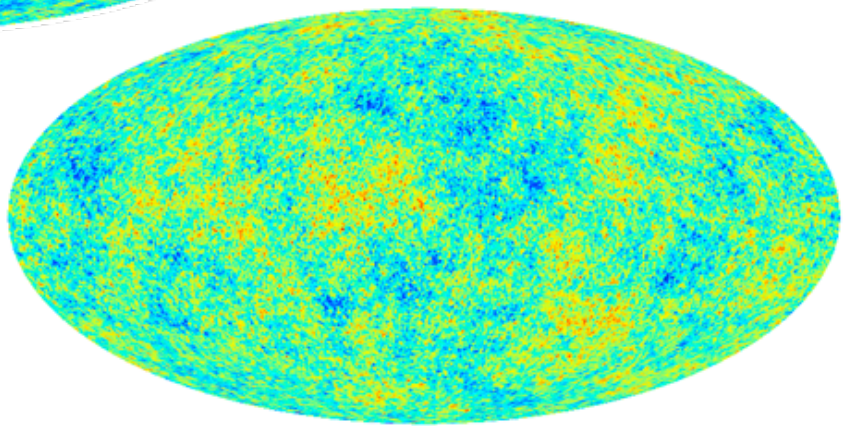
f_{NL}= 0



f_{NL}= +5000



f_{NL}= +500



Using publicly available NG maps by Elsner & Wandelt

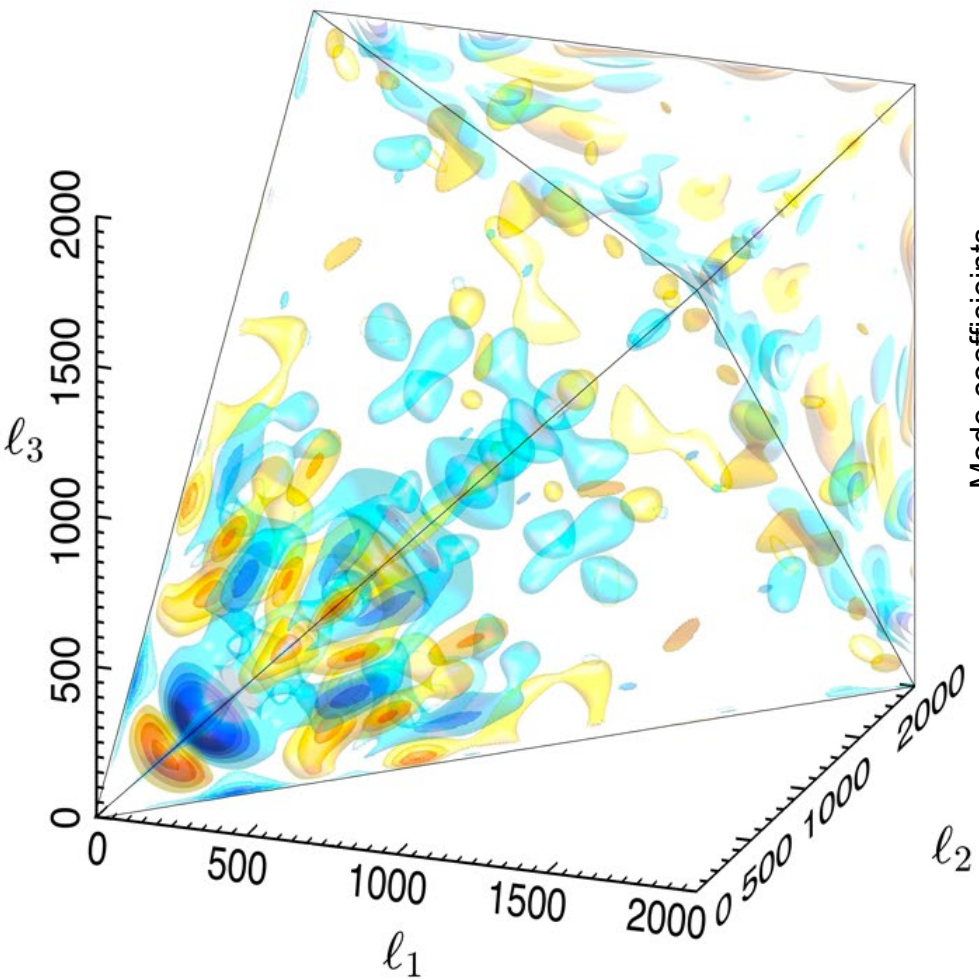
Constraints from Planck

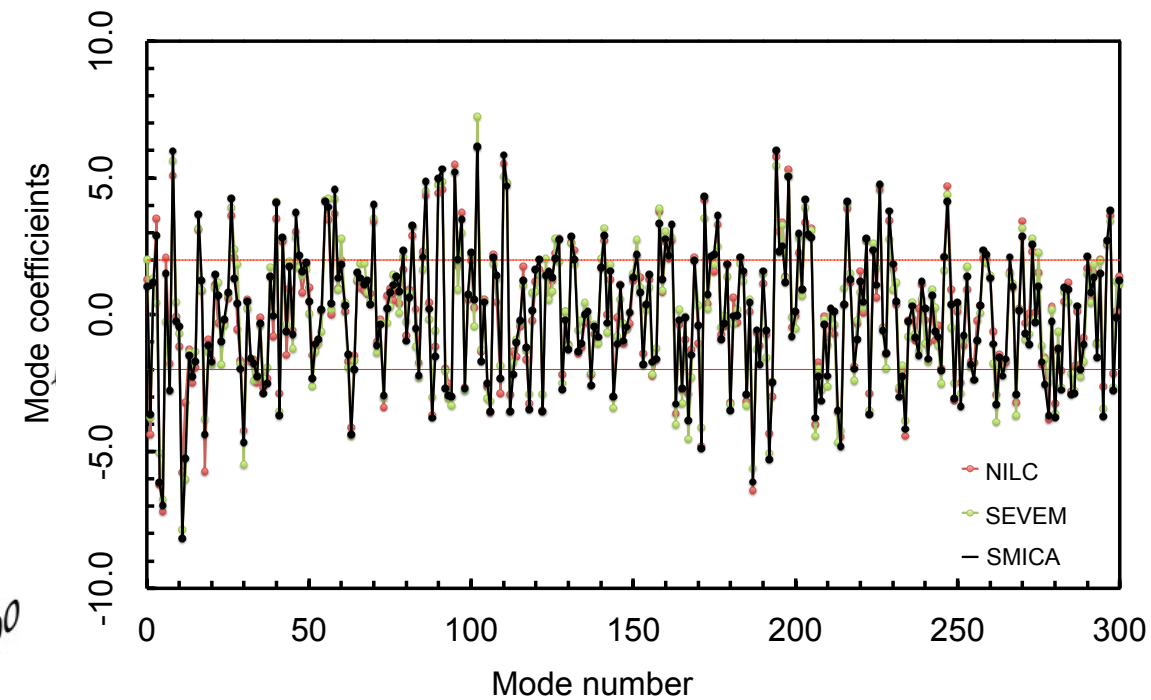
	ISW-lensing subtracted		
	KSW	Binned	Modal
SMICA			
Local	**2.7 ± 5.8**	2.2 ± 5.9	1.6 ± 6.0
Equilateral	**−42 ± 75**	−25 ± 73	−20 ± 77
Orthogonal	**−25 ± 39**	−17 ± 41	−14 ± 42
NILC			
Local	4.5 ± 5.8	3.6 ± 5.8	2.7 ± 6.0
Equilateral	−48 ± 76	−38 ± 73	−20 ± 78
Orthogonal	−53 ± 40	−41 ± 41	−37 ± 43
SEVEM			
Local	3.4 ± 5.9	3.2 ± 6.2	2.6 ± 6.0
Equilateral	−36 ± 76	−25 ± 73	−13 ± 78
Orthogonal	−14 ± 40	−9 ± 42	−2 ± 42
C-R			
Local	6.4 ± 6.0	5.5 ± 5.9	5.1 ± 5.9
Equilateral	−62 ± 79	−55 ± 74	−32 ± 78
Orthogonal	−57 ± 42	−41 ± 42	−42 ± 42

Planck collaboration XXIV, 2013

Constraints from Planck: modal expansion

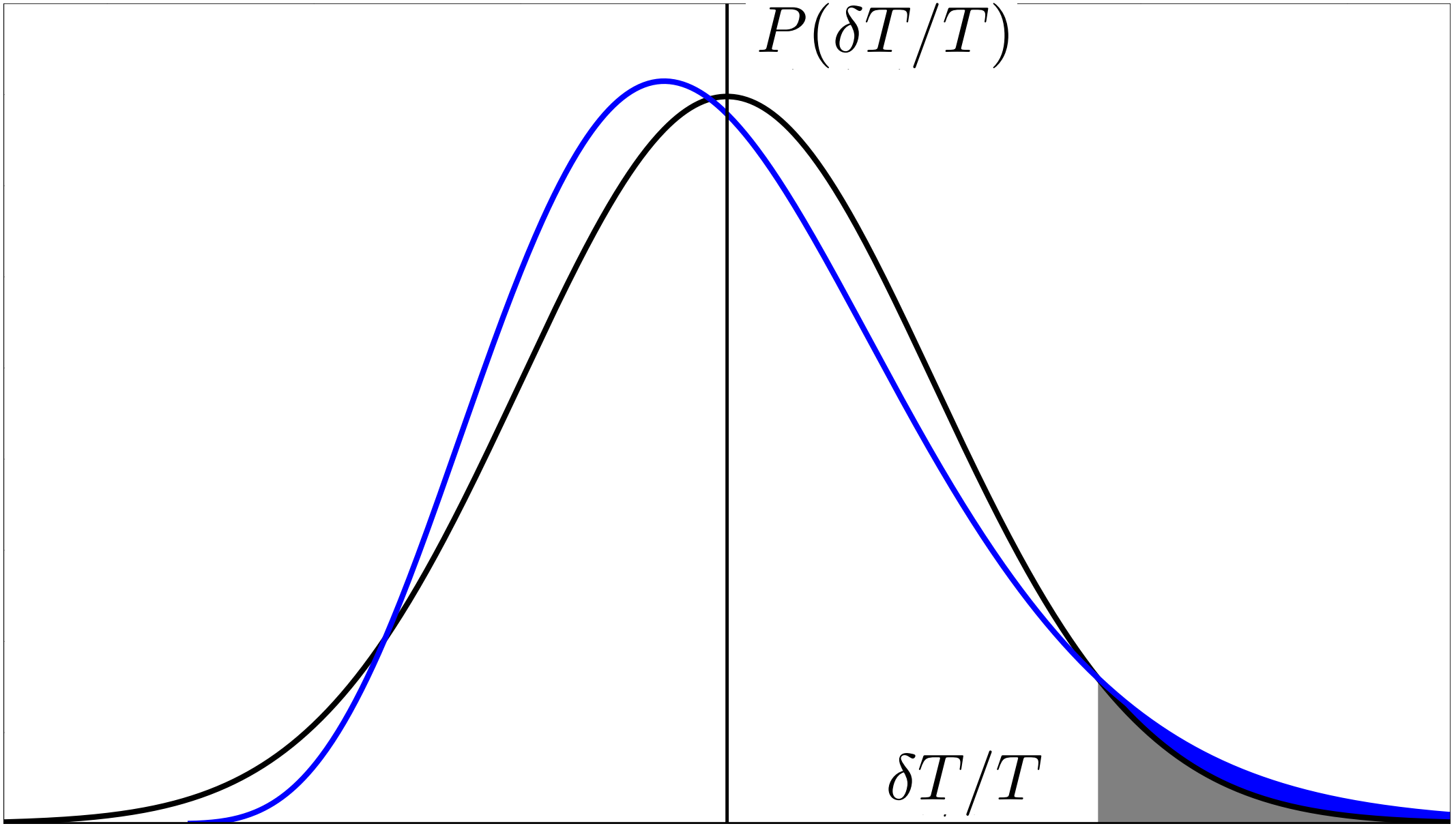
$$B(k_1, k_2, k_3) = \sum_{p,r,s} \alpha_{prs}\, q_p(k_1) q_r(k_2) q_s(k_3)$$





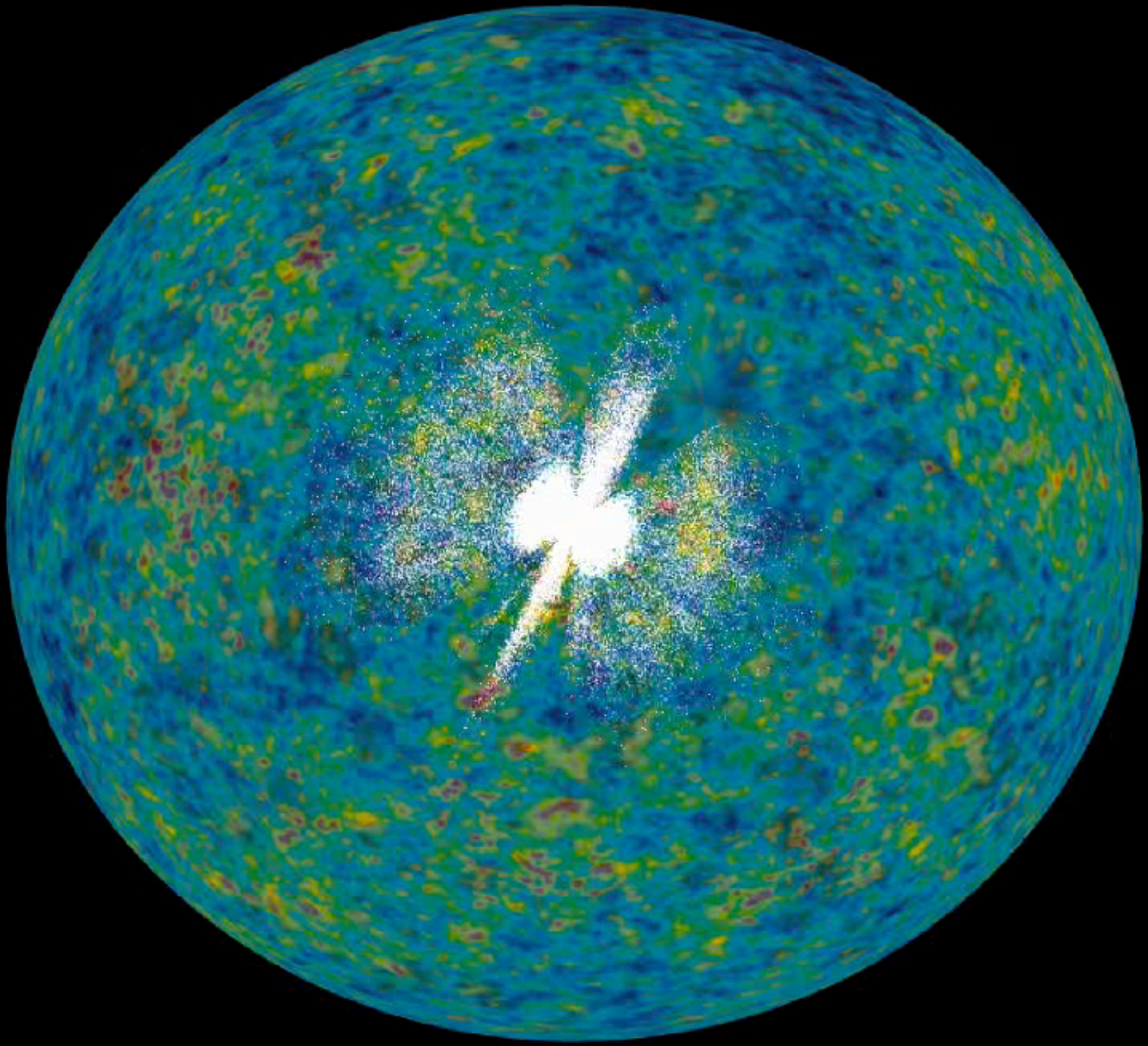
Planck collaboration XXIV, 2013

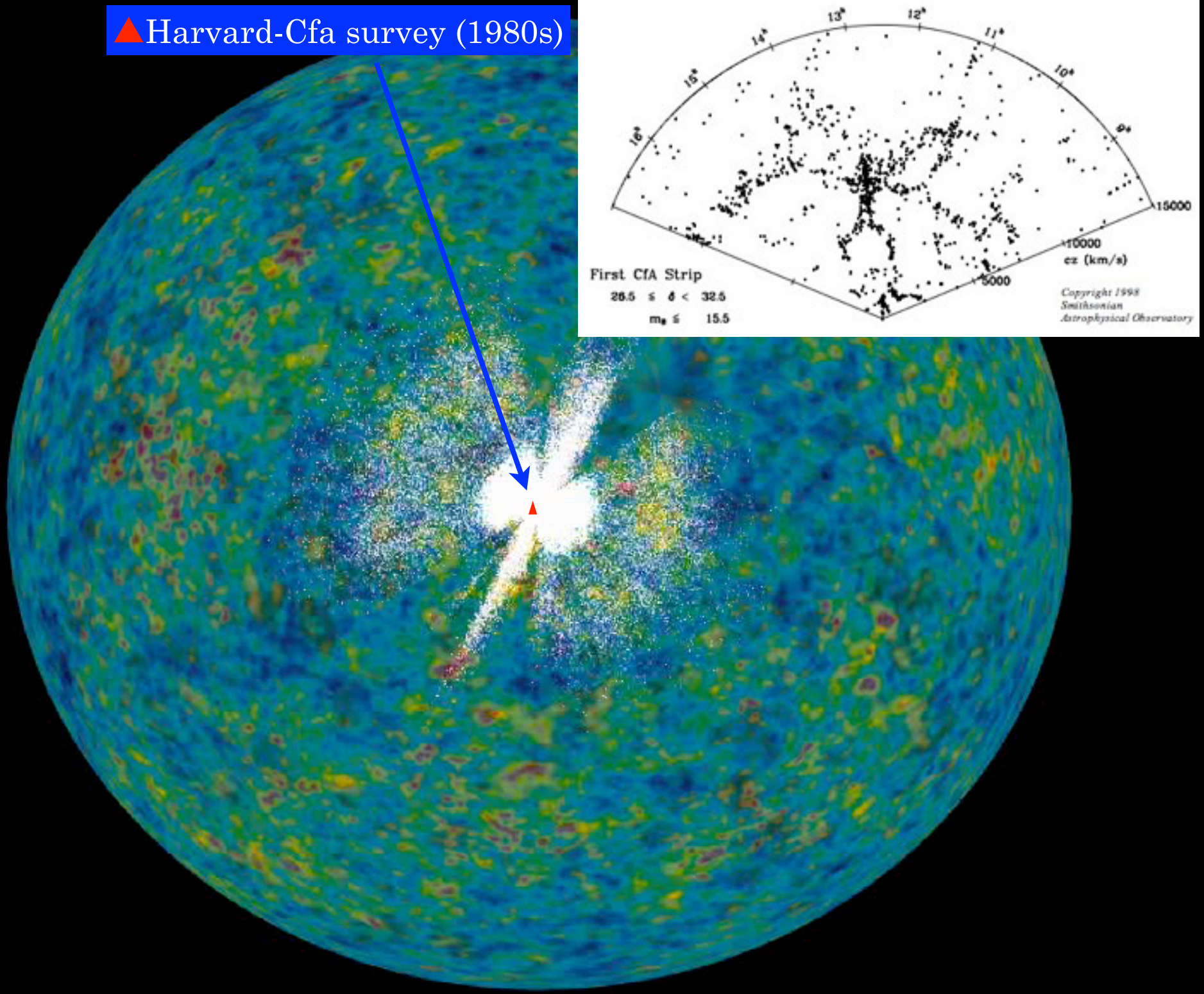
Current upper bound on NG is
~1000 times smaller than this:

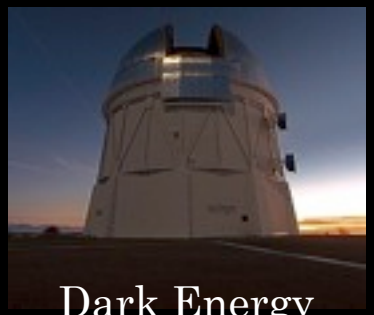


Next Frontier: Large-Scale Structure

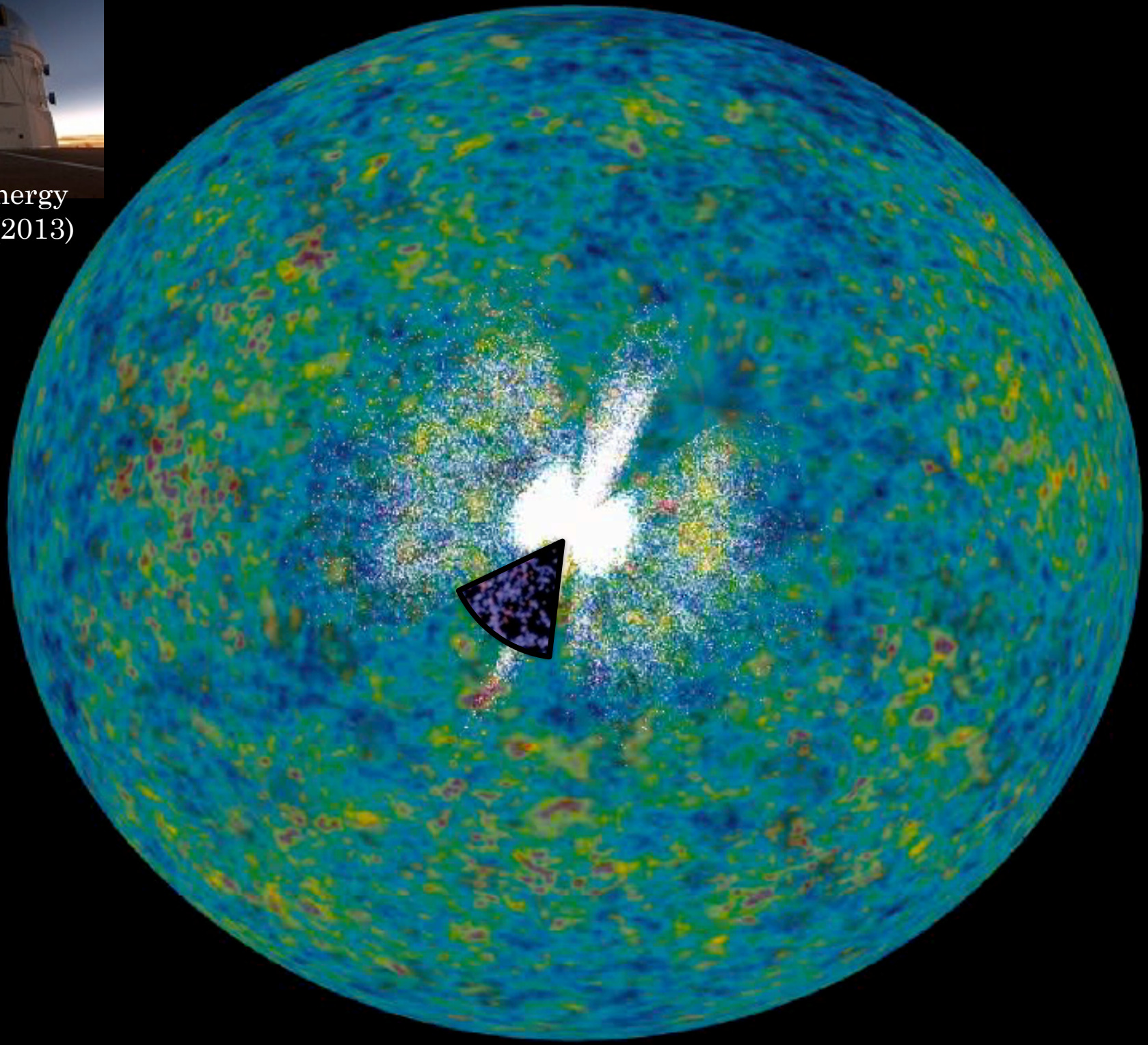
	CMB	LSS
dimension	2D	3D
# modes	$\propto l_{max}^2$	$\propto k_{max}^3$
systematics & selection func.	relatively clean	relatively messy
temporal evol.	no	yes
can slice in	λ only	λ, z, M, bias...

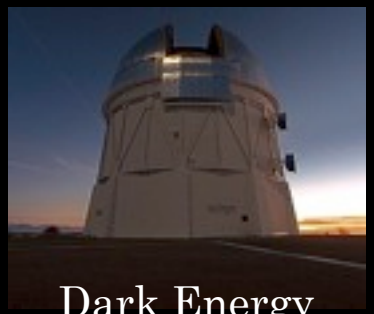



Harvard-Cfa survey (1980s)
First CfA Strip
26.5 ≤ δ < 32.5
m_B ≤ 15.5
15000
10000
cz (km/s)
5000
Copyright 1998
Smithsonian
Astrophysical Observatory

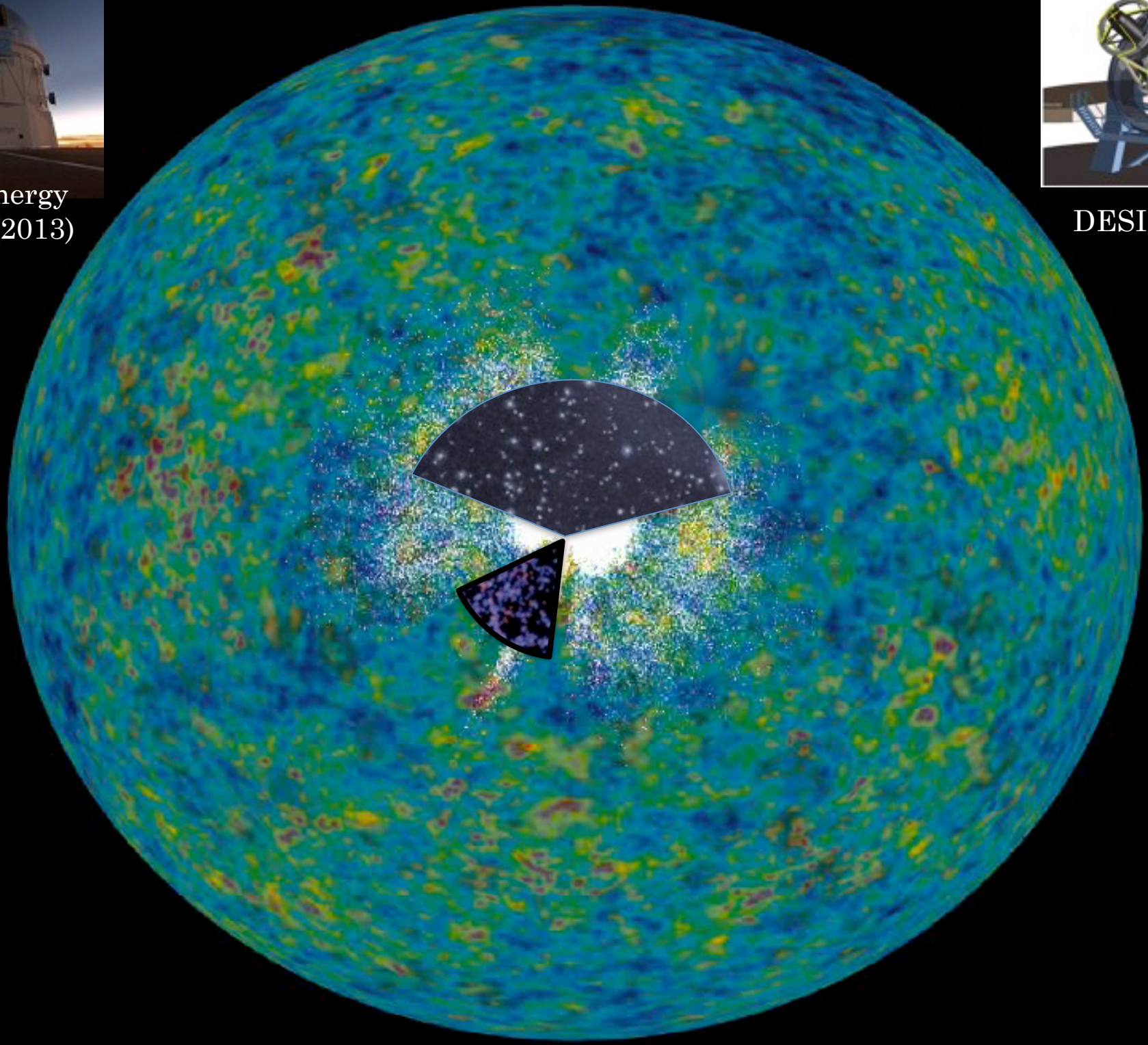


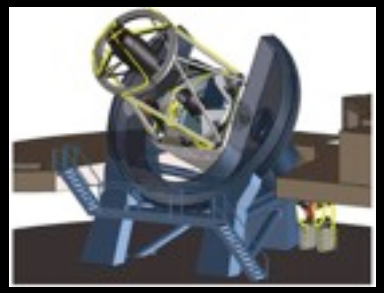
Dark Energy Survey (2013)



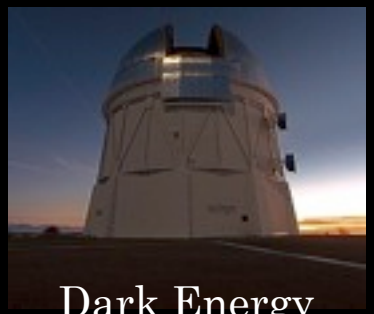


Dark Energy Survey (2013)

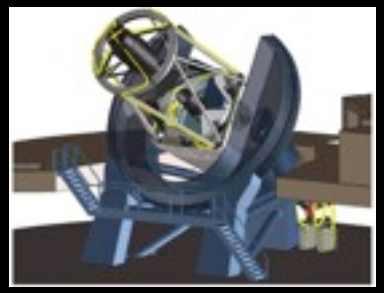




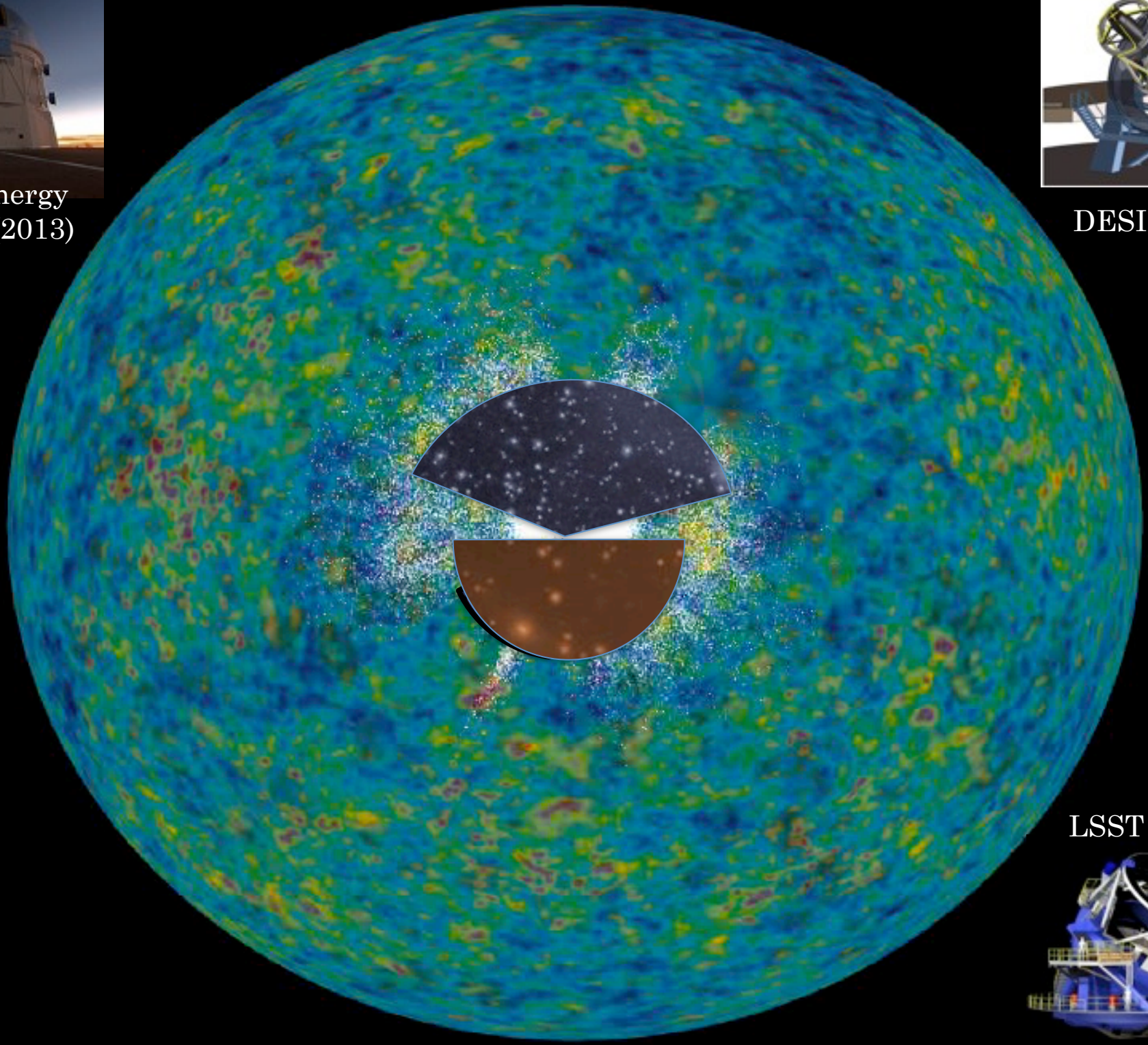
DESI (~2017)



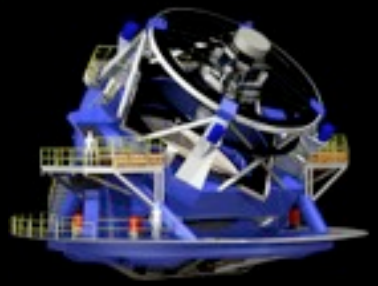
Dark Energy Survey (2013)

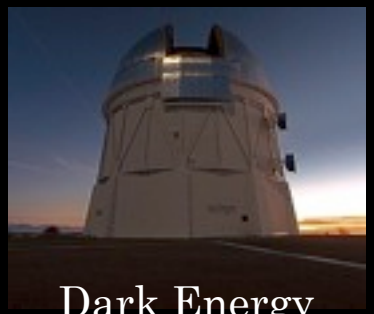


DESI (~2017)

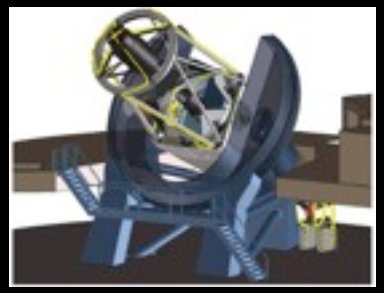


LSST (~2020)

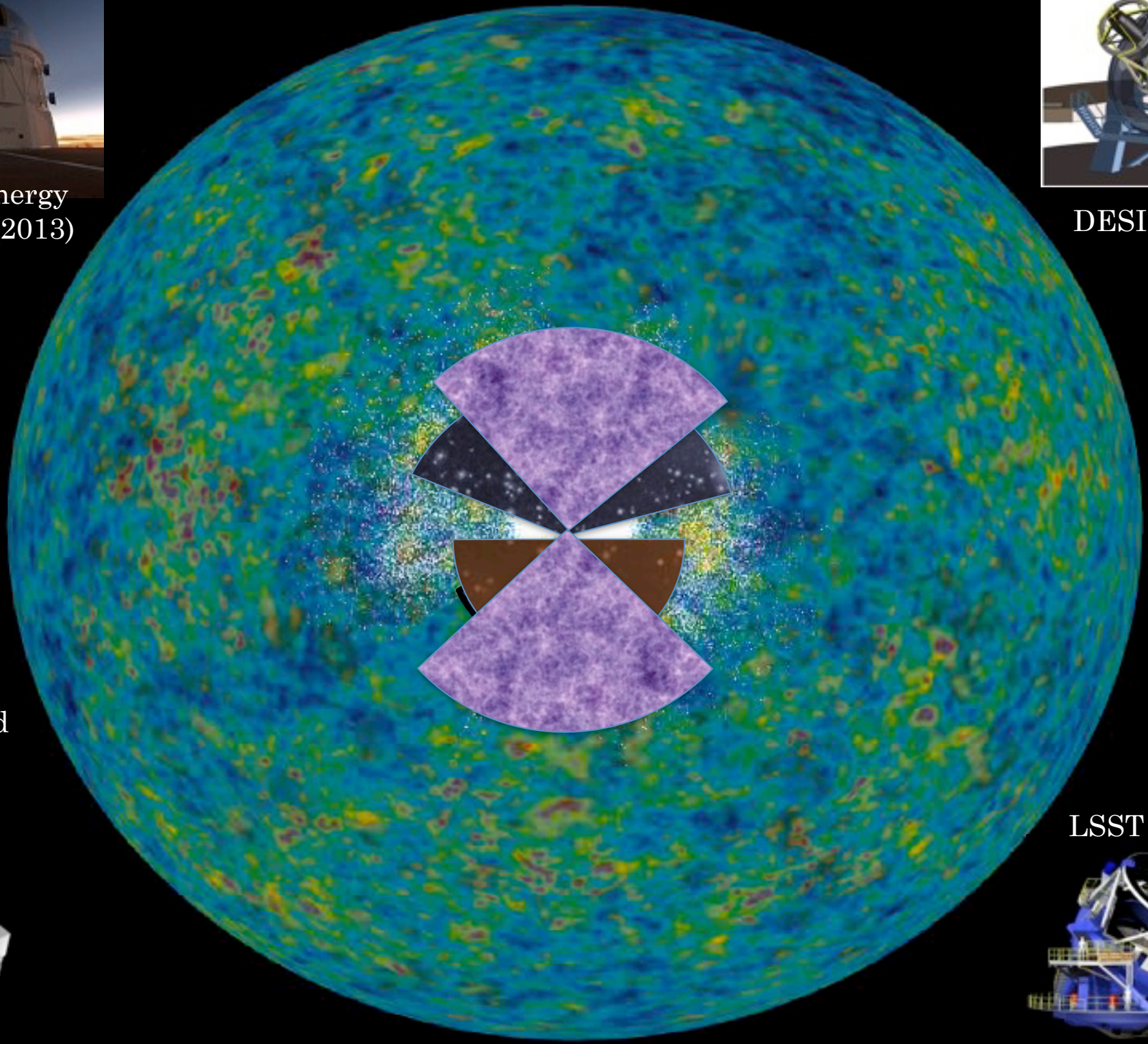




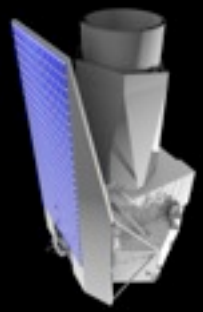
Dark Energy Survey (2013)



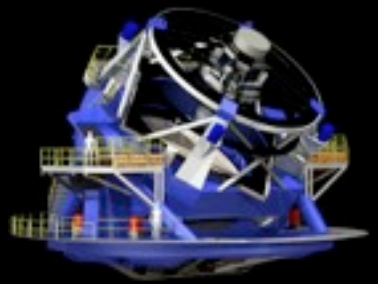
DESI (~2017)

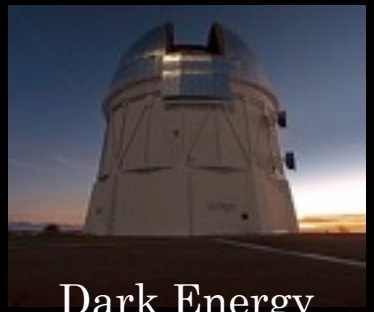


Euclid and WFIRST (~2025)

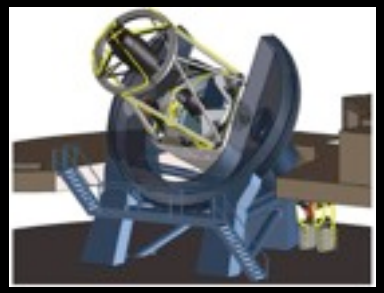


LSST (~2020)

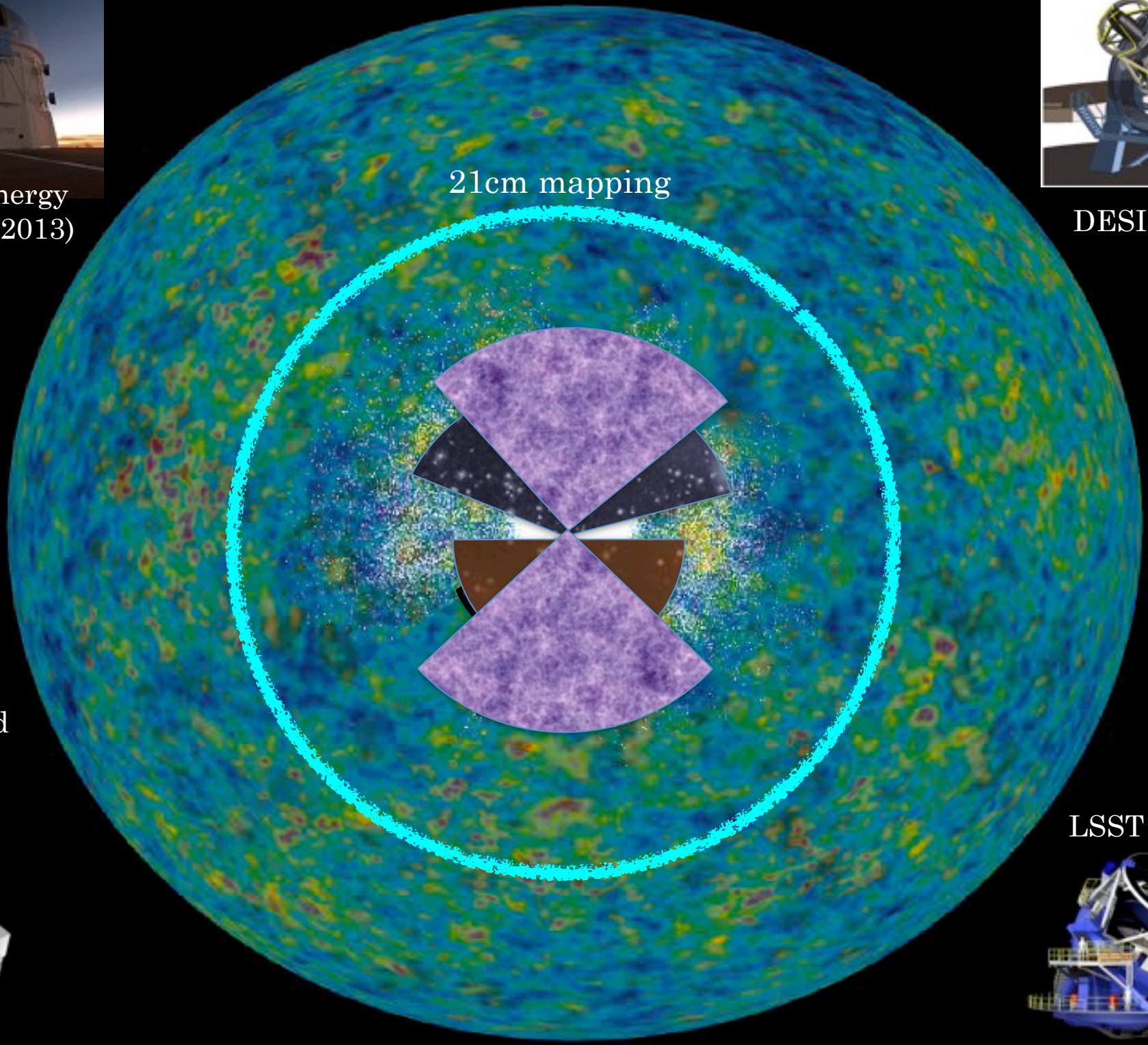




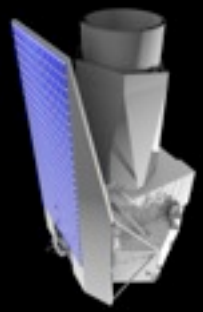
Dark Energy Survey (2013)



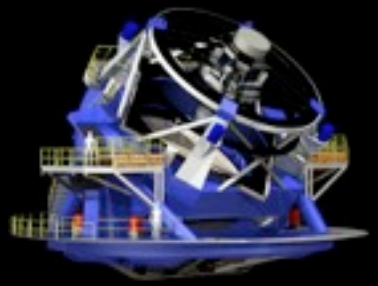
DESI (~2017)



Euclid and WFIRST (~2025)

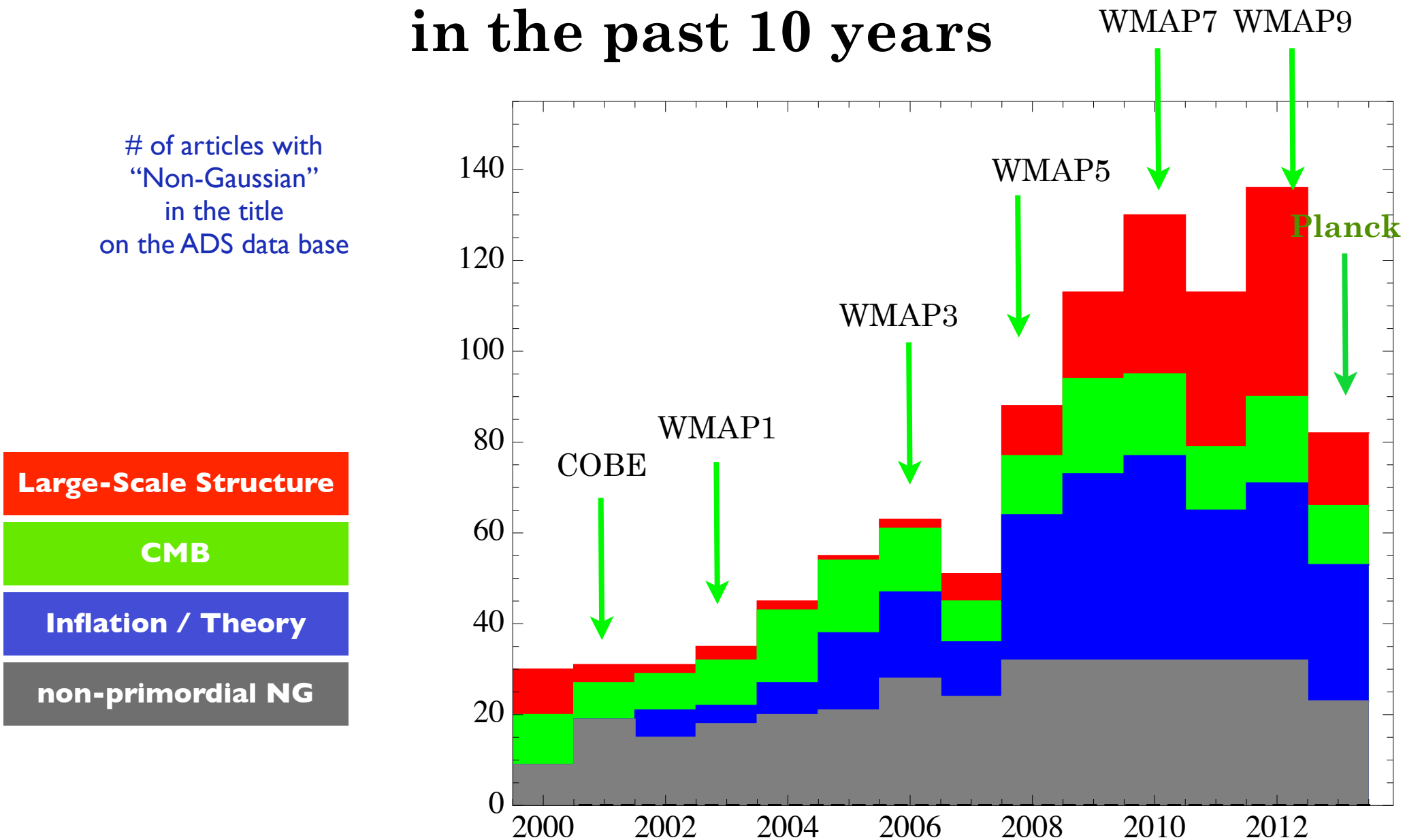


LSST (~2020)



Non-Gaussianity papers in the past 10 years

of articles with
"Non-Gaussian"
in the title
on the ADS data base

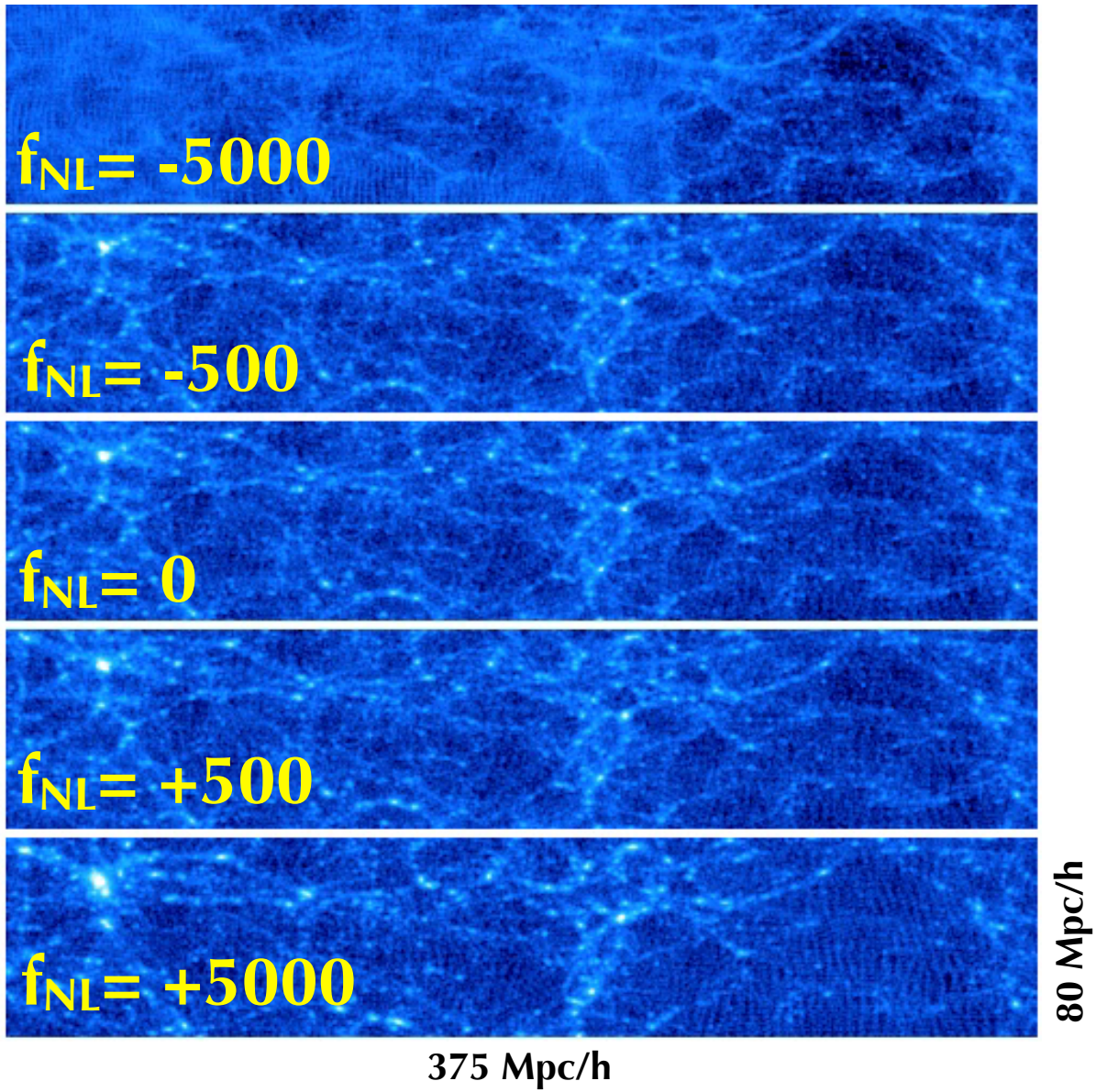


Produced by Emiliano Sefusatti

Large-Scale Structure in Three Easy Steps:

Step 1:
Produce theory predictions
(including from simulations)

Simulations with non-Gaussianity (f_{NL})

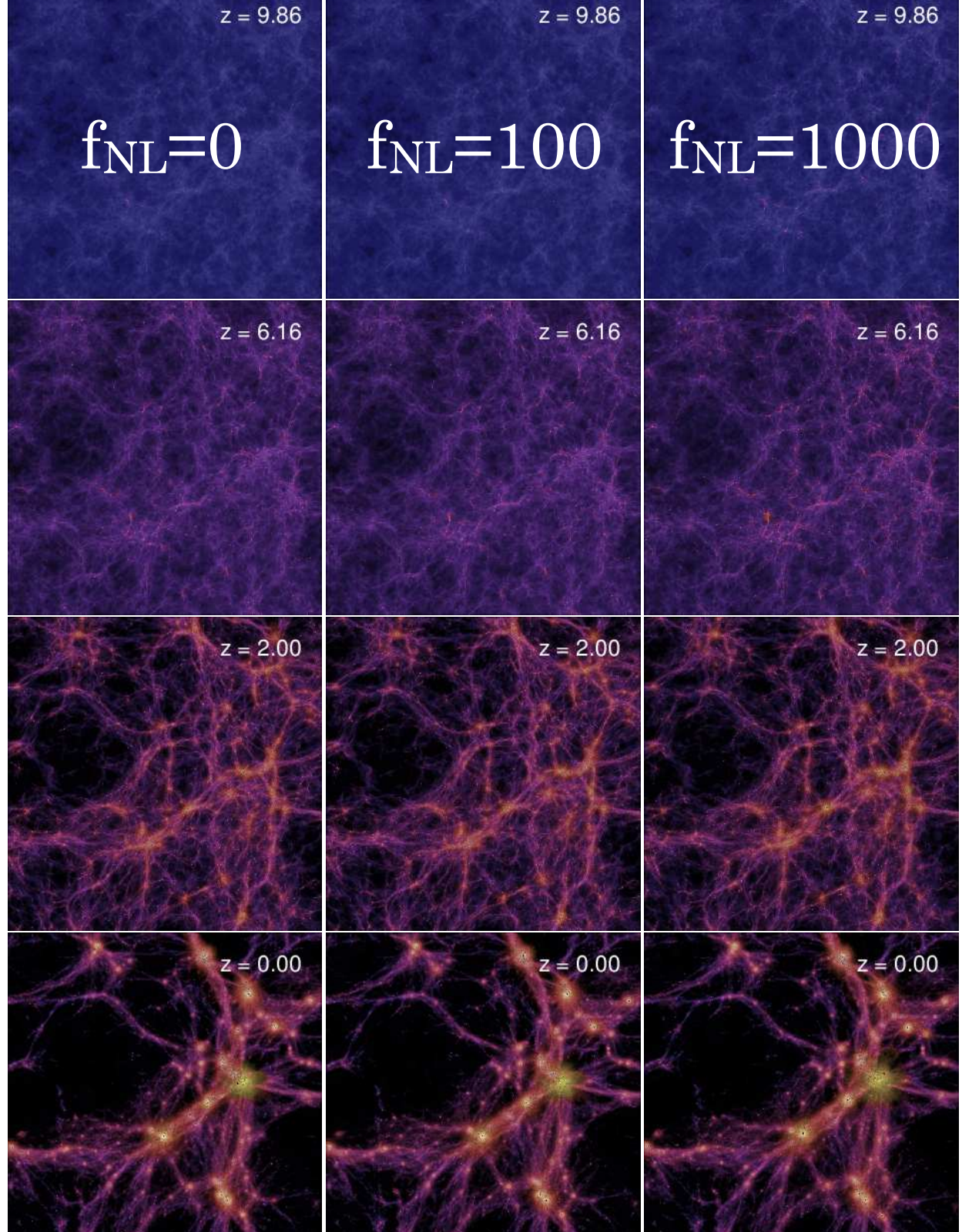


- Under-dense region evolution decrease with f_{NL}
- Over-dense region evolution increase with f_{NL}

- Same initial conditions, different f_{NL}
- Slice through a box in a simulation $N_{part}=512^3$, L=800 Mpc/h

Dalal et al. 2008

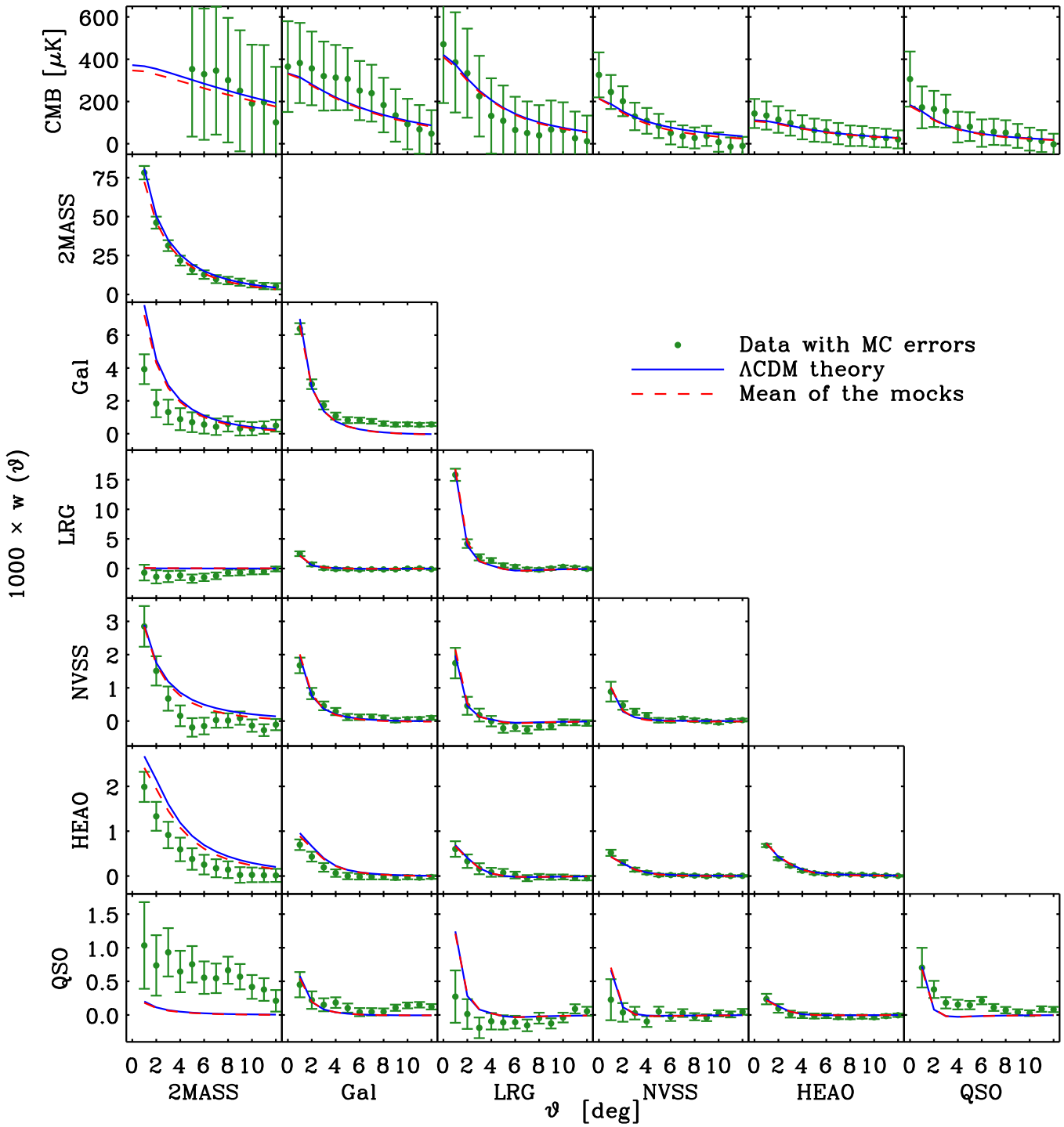
...and now with baryons!



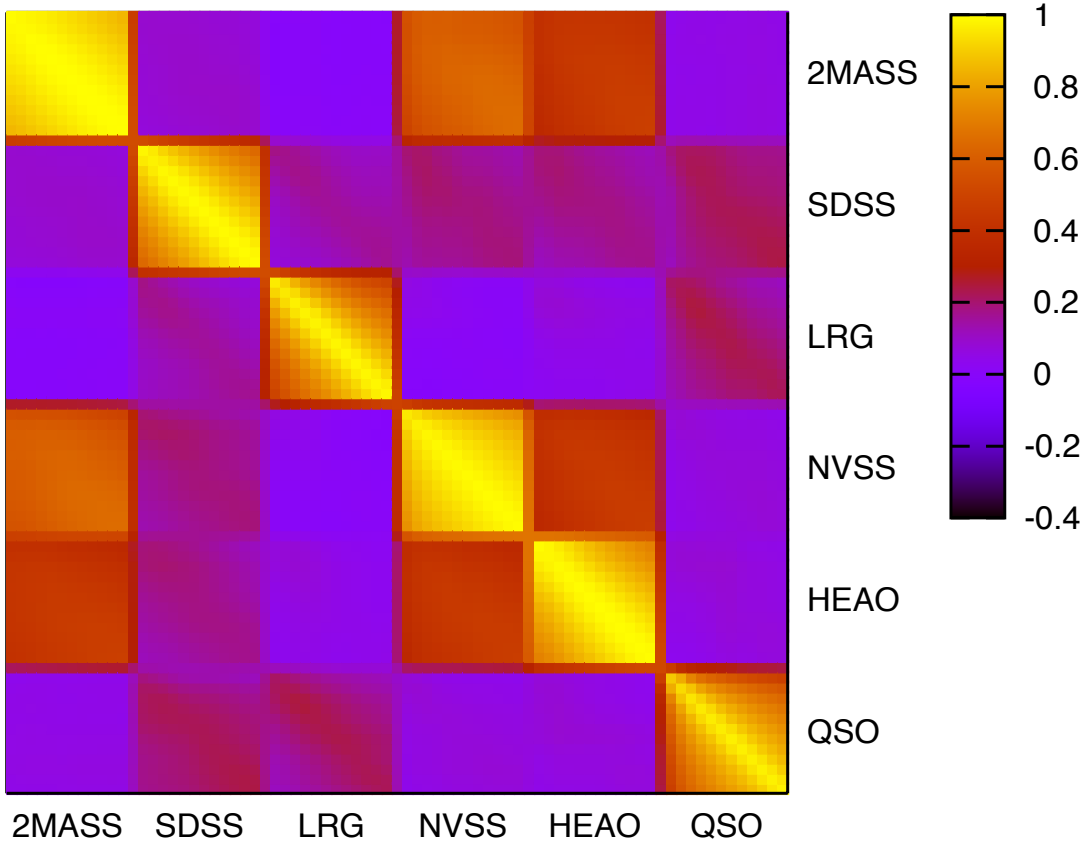
Zhao, Li,
Shandera & Jeong,
arXiv:1307.5051

Step 2:
Use multiple LSS probes in dataset

Using LSS (and CMB) tracers - correlation functions

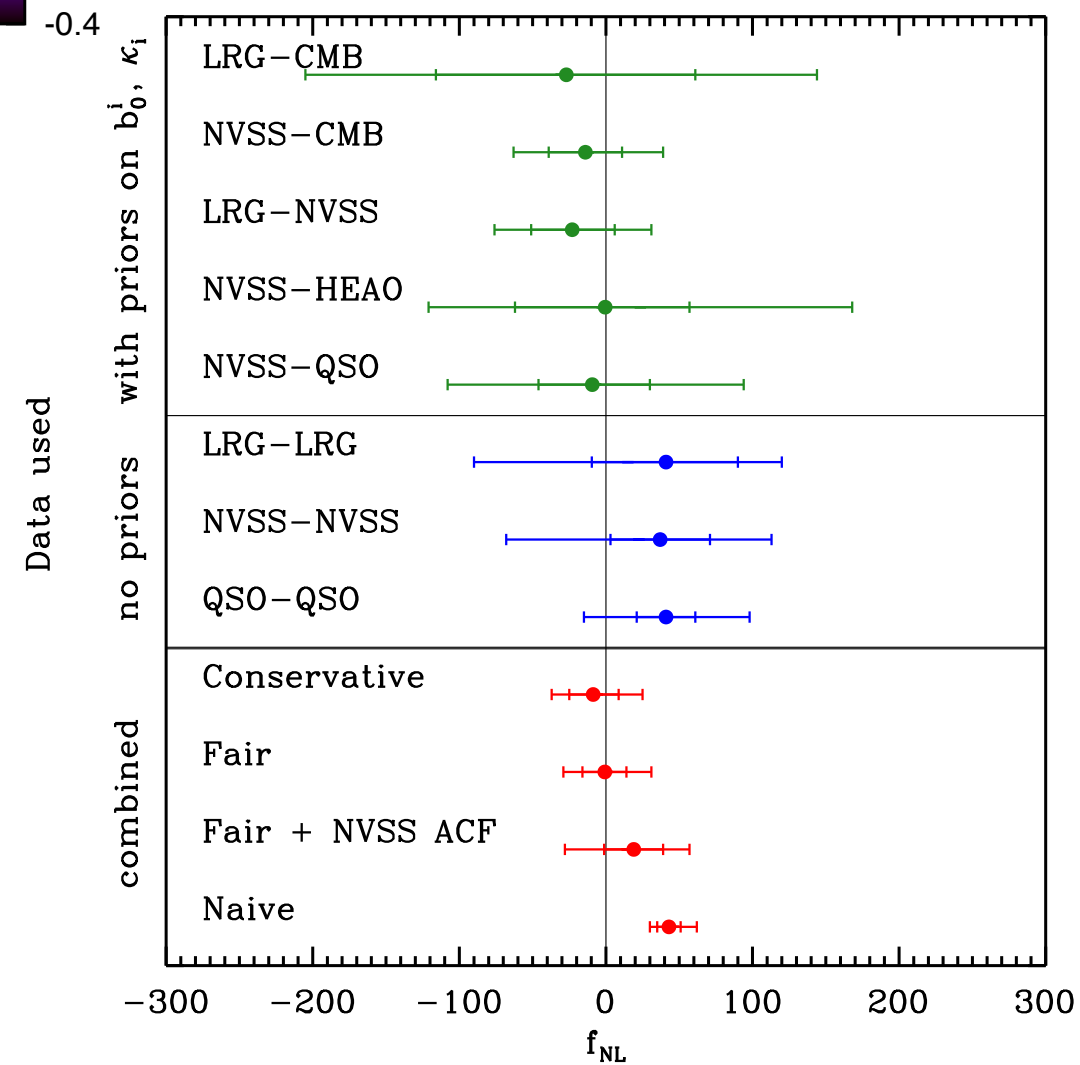


Giannantonio et al. 2013



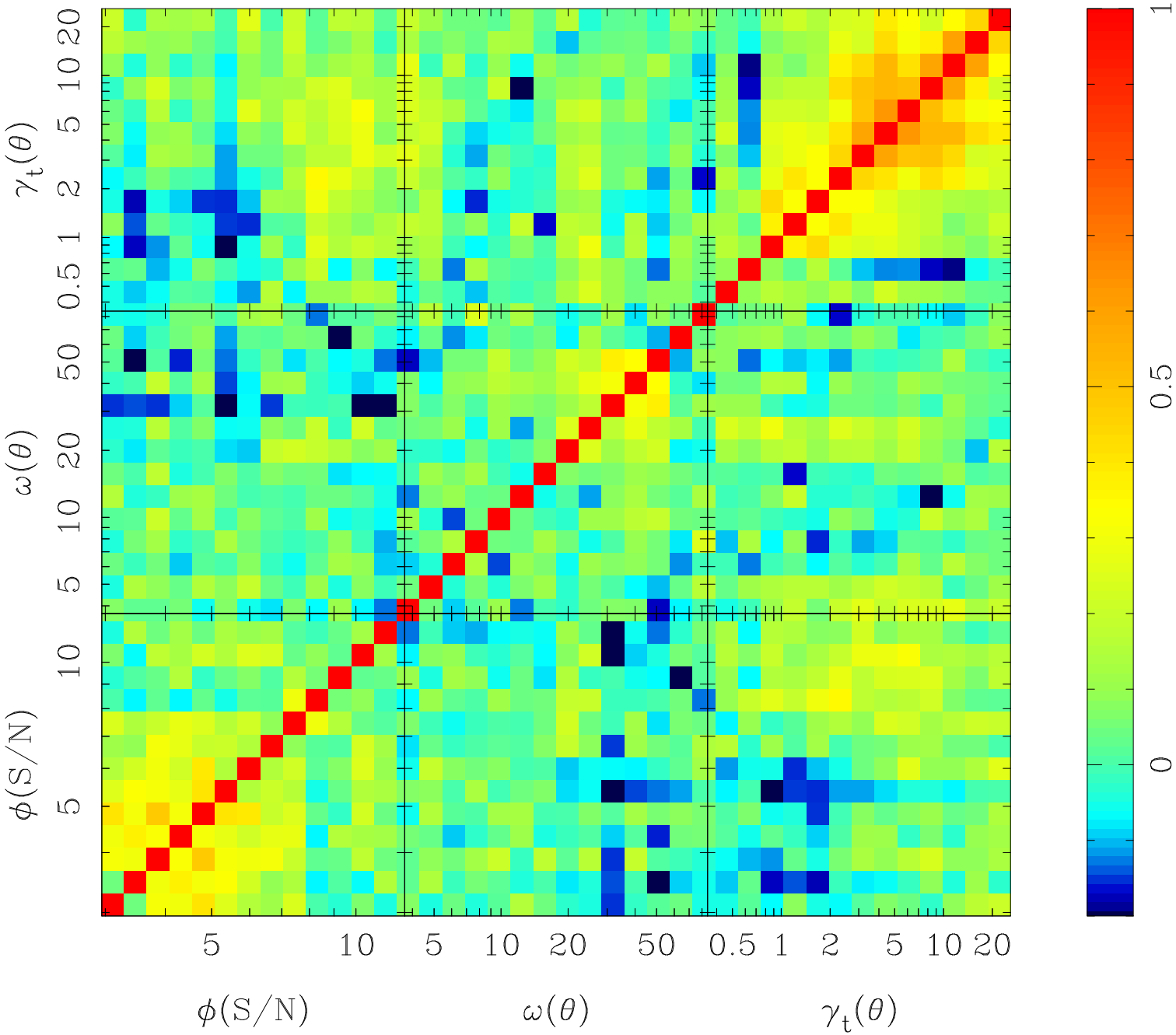
Covariance matrix

Final constraints:



Giannantonio et al. 2013

Covariance of weak lensing probes



results from numerical simulations

Marian, Smith et al. 2013

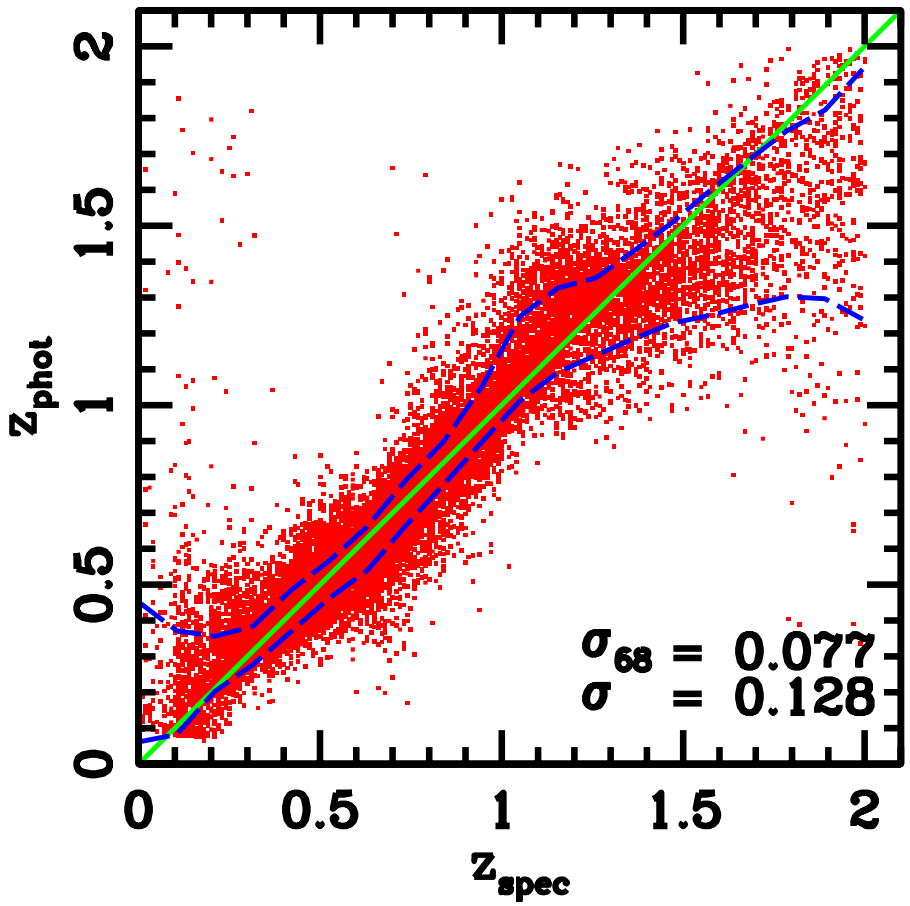
Step 3:
Control the Systematic Errors

Systematic errors

- Already a limiting factor in measurements
- Will definitely be limiting factor with Stage-IV quality data
- Quantity of interest: (true sys. – estimated sys.) **difference**
- **Self-calibration**: measuring systematics internally from survey

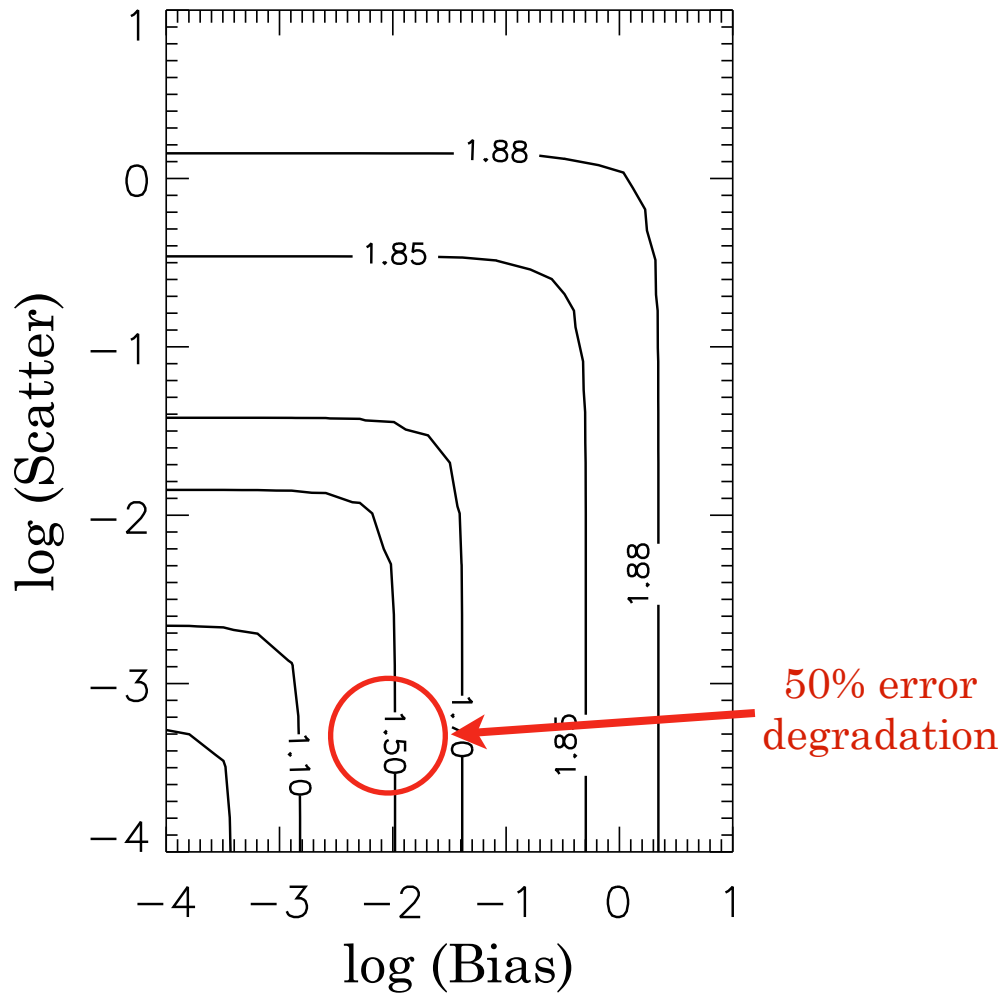
Example I: photometric redshift errors

z_{phot}-z_{spec}
from "training set"



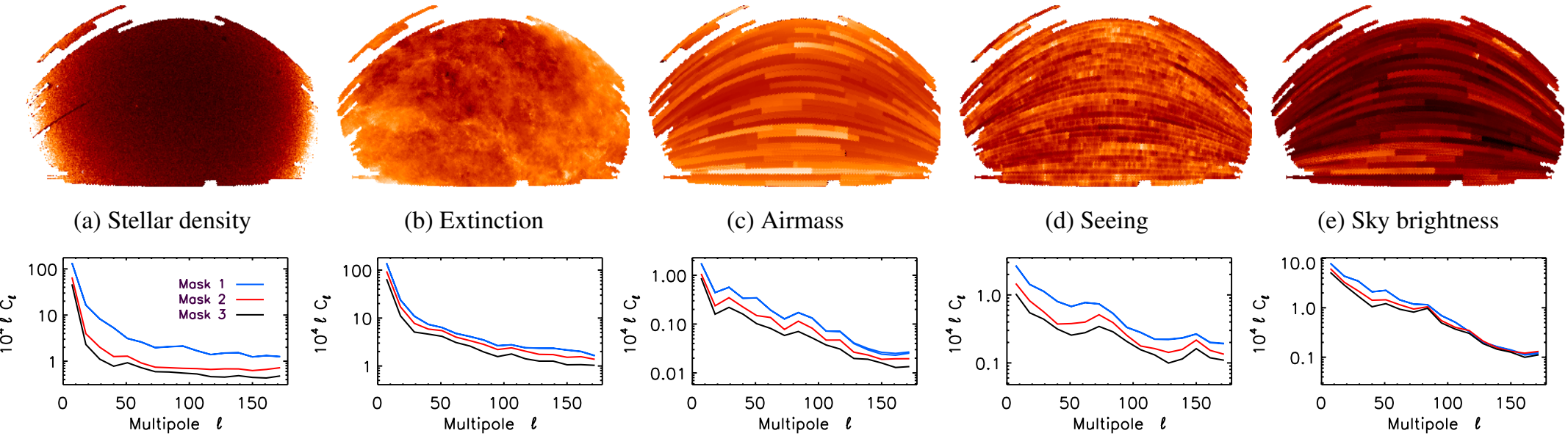
C. Cunha

Requirements



Ma, Hu & Huterer 2006

Example II: LSS calibration errors

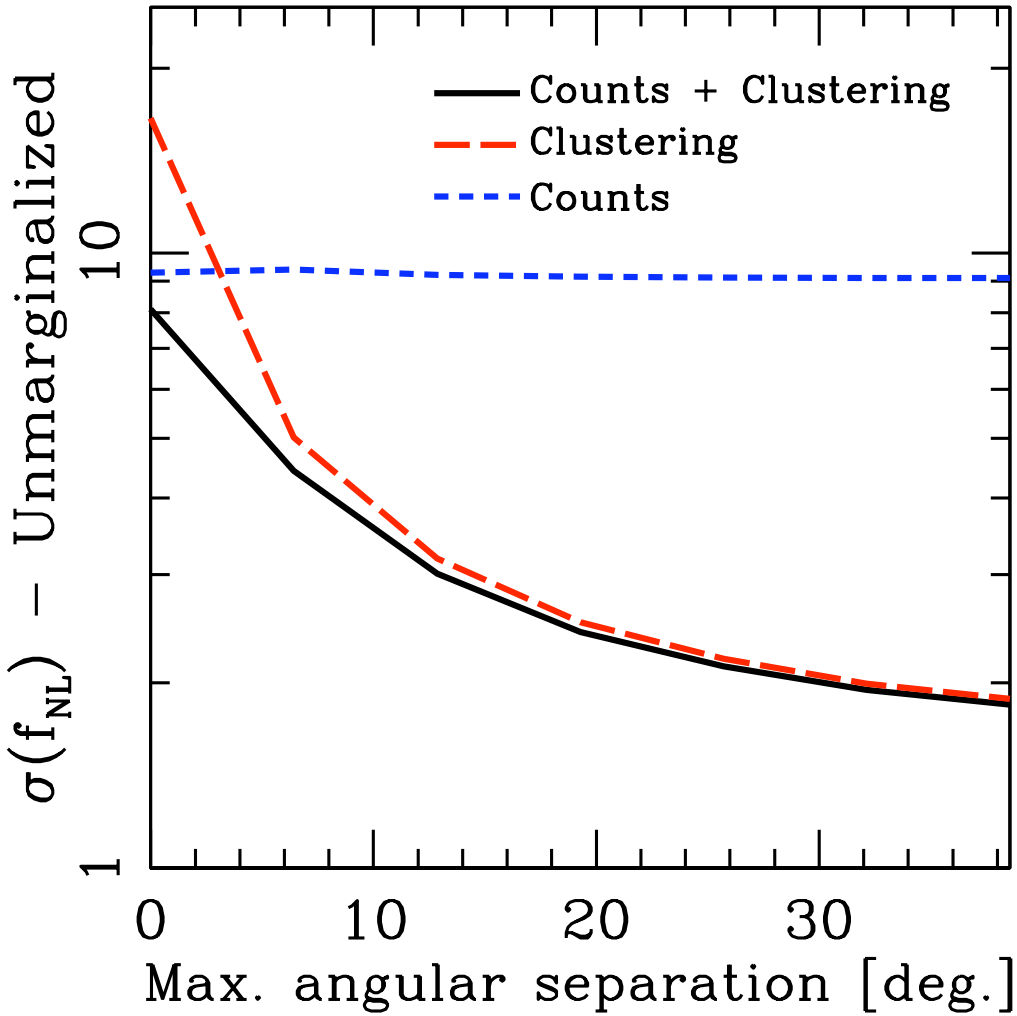


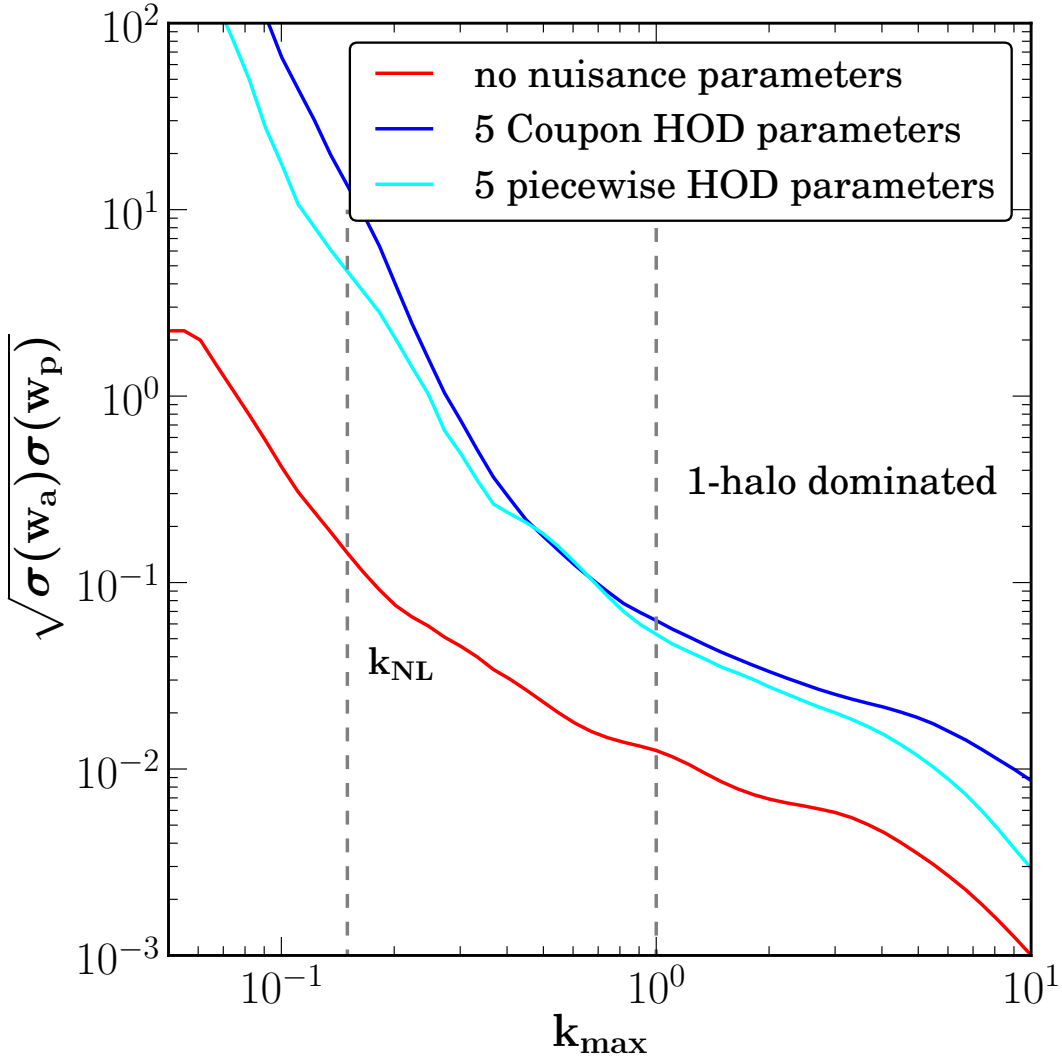
- dominate on large angular scales
- can be measured, removed using same or other data

Leistedt et al 2013
see also Ho et al 2012; Huterer et al 2013

Conclusion:

LSS has a lot to offer;
many handles on both physics (NG/DM/DE) and systematics





Cunha, Huterer & Doré 2010

Heidi Wu